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FRANK EUGENE LUTZ

Dr. Frank E. Lutz, Chairman and Curator of the Department of Insects and Spiders of the American Museum of Natural History for the last twenty-two years and member of the Scientific Staff of that institution for thirty-four years, died on November 27, after several weeks of illness at the age of 64. He was born at Bloomsburg, Pa., on September 15, 1879. He attended Haverford College and the University of Chicago and received his final degree from the latter institution in 1907. From 1904 until 1909, he was attached to the Department of Genetics of the Carnegie Institution. In 1909 he went to the American Museum of Natural History as Assistant Curator in the Department of Invertebrate Zoology, and he served as Associate Curator of that department from 1917 to 1921. When the Department of Entomology was created as a separate entity in 1921, he was appointed Curator.

Doctor Lutz was noted as a scientist and educator for his work in two fields; for his research in biology and insect physiology and for his work in popular entomology and nature study. He is known to tens of thousands of readers for his *Field Book of Insects,* first published in 1917. In the early part of the century his experiments and subsequent papers on evolution and heredity in fruit flies were among the first contributions dealing with the genetics of these insects. Throughout his entire career he was interested in the "hows and whys" of insect habits. His studies of ultra-violet color patterns of flowers; his recordings of insect sounds; his studies of wind and insect flight, and diurnal rhythms, opened entirely new fields in the study of insect behavior. Doctor Lutz always claimed that his most interesting experiments were made in his own back yard and cellar. The unusual mechanical devices he invented for some of these studies are described in his recently published book *A Lot of Insects,* which is based on the insects of his suburban garden.

Doctor Lutz was a leader in popular education and in conservation. After beginning the first "trailside museum" at Bear Mountain, N. Y., in the summer of 1926, he was called upon by many organizations for advice in establishing similar nature-trails in park and wildlife areas throughout the United States. He was a fellow of the American Association for the Advancement of Science and of the New York Academy of Sciences, charter member and fellow of the Entomological Society of America (of which he was president in 1927); member of the American Society of Zoologists, member and past president of the New York Entomological Society, and a member of a number of other scientific organizations. In 1923 he was awarded the Morrison Prize for his essay on "The Colors of Flowers and the Vision of Insects with Special Reference to Ultraviolet," which embodied the results of his experiments as chairman of the Committee on Biological Relations Between Flowers and Insects, of the National Research Council. He was also an advisor to the Buffalo Society of Natural Sciences. From 1925 to 1928 he directed the Station for the Study of Insects at Tuxedo, N. Y.

Doctor Lutz is survived by his widow, Mrs. Martha Ellen Brobson Lutz, and by four children; a son, Frank Brobson Lutz, and three daughters, Anna Lutz, Ensign Laura Lutz, and Mrs. Boyd Sherman.

THE DIMORPHISM IN THE MALE COPULATORY ORGAN OF THE CHRYSOMELID *ARTHROCHLAMYS BEBBIANAE* BROWN*

BY W. J. BROWN,
Ottawa, Ontario

Arthrochlamys bebbianae Brown is a small chrysomelid that occurs rather commonly in the Ottawa District. It is one of a group of species that have been confused under the names *Chlamys gibbosa* (Fab.) and *C. plicata* (Fab.). Both its larvae, which are case-bearers, and its adults feed on the leaves and on the epidermis of the new growth of a willow, *Salix Bebbiana* Sarg. The species appears to be monophagous, and it tends to occur in diffuse colonies.

The type series of *bebbianae* included thirty-one males, all of which were taken from their food-plant in the Ottawa District as mature larvae, pupae, or newly emerged adults during late summer in 1942. These males possessed copulatory organs of two distinct types (fig. 1). The differences concerned the apex of the organ and the form of the sclerotized structures of its internal sac.

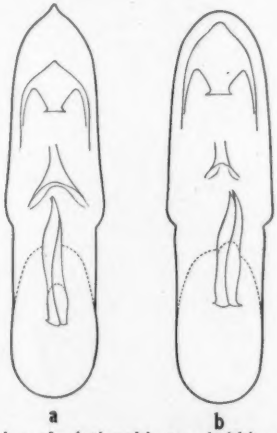

Fig. 1. The median lobe of *Arthrochlamys bebbianae* Brown; *a*, typical form; *b*, atypical form.

They were of the same order as differences known to distinguish species in the genus. However, it was concluded provisionally (1) that a single dimorphic species was concerned, because the beetles with organs of different types occurred together, restricted their feeding to the same plant, and were inseparable by other characters. During 1943, additonal specimens were collected, and the progeny of several females was reared. Renewed study confirmed the occurrence of copulatory organs of distinct types, as well as the occurrence of variation of a continuous nature. Two of the confined females produced offspring with organs of both types. Males of *bebbianae* vary in size, color, and sculpture, but those with different types of copulatory organs vary around the same means as regards these other characters. Thus it seems unlikely that the differences in the organs are due to environmental or growth factors. The occurrence of true dimorphism, demonstrated by the rearing mentioned above, is indicated.

In *Arthrochlamys*, the copulatory organ is of a common chrysomelid type. It consists of a rather small, Y-shaped tegmen and a large median lobe. The median lobe (fig. 1) is a curved, flattened tube. Its subapical opening, the median orifice, is dorsal and large and is closed in part by flap-like margins

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which are continuous with the internal sac. The internal sac is contained within the median lobe; it is membranous but contains sclerotized structures which, together with the sac, are evaginated through the median orifice during copulation. The sclerotized parts of the sac are an anterior structure and a flagellum. The latter is a tube that is paired, pointed anteriorly, and obliquely truncate posteriorly, the entire truncation being occupied by an orifice. These parts can be observed in situ through the transparent wall of the median lobe when the latter is mounted in Canada balsam, and they are so shown in figure 1.

Table 1. The Male Copulatory Organs of the Progeny of Seven Females of *Arthrochlamys bebbianae* Brown.

Female	Male Progeny		
	Typical form	Atypical form	Unclassified
B[1]	6	3	1
C[1]	—	6	—
D[1]	1	2	—
H[2]	4	—	—
I[3]	4	—	—
J[2]	4	—	—
K[2]	—	3	—

[1]Mated with a typical and with an atypical male before laying.
[2]Mated with an atypical male while laying.
[3]Mated with a typical male before laying.

The following notes are based on fifty males collected as mature larvae, pupae, or adults and including the type series, and on thirty-four males reared in the laboratory as the progeny of seven females. The copulatory organs of all are mounted in Canada balsam on slides. In thirty-five of the collected specimens (fig. 1, *a*), the apex of the median lobe is acutely pointed, feebly deflexed, and prolonged well beyond the median orifice, and the orifice of the flagellum is relatively small, occupying from 26.6 to 39.2 per cent of the flagellar length with an average of 34.8 per cent. Organs of this type are termed the 'typical form' in the following notes. In the remaining fifteen specimens of the collected series (fig. 1, *b*), referred to below as the 'atypical form', the apex of the median lobe is rounded, not deflexed, and scarcely prolonged beyond the median orifice, and the orifice of the flagellum is larger, occupying from 45 to 63 per cent of the flagellar length with an average of 53.5 per cent. There is variation in the form of the apex of the median lobe, as well as in the size of the flagellar orifice, but the variation is strongly discontinuous. Thus the apex is a little more acute in some examples of the typical form than in others, and in two specimens of the atypical form, the apex is feebly rounded on each side and is therefore very bluntly and very obtusely pointed. In several of the atypical form, the apex extends very slightly farther beyond the median orifice than in others. The two forms differ also in the shape of the flagellum and in the development of the anterior sclerotized structure of the internal sac, but these differences are less constant. The flagellum is usually much more elongate in the typical than in the atypical form, but two of the specimens, one of each form, cannot be placed on the basis of this character alone. The anterior sclerotized structure of the sac is usually larger in the typical than in the atypical form, but it varies considerably in both.

The seven females, from the eggs of which thirty-four males were reared, were taken in the Ottawa District during the last ten days of May, 1943. Table 1 shows the form of the copulatory organs of their male progeny. Probably all of the females had mated before they were collected. As it was possible to observe the form of the median lobe in males attempting to copulate, the females

were mated in the laboratory as shown in Table 1. All of the reared males, except those from 'female C' and some from 'female B', compare well with the collected series. In those from 'female C', the orifice of the flagellum is unusually large, occupying from 59.1 to 68.3 per cent of the flagellar length, with an average of 63.9 per cent, as against 45 to 63 per cent, average 53.5 per cent, in the collected males of the atypical form. Of the ten males from 'female B', four of the typical form and three of the atypical compare well with the collected series. In two of the specimens, the median lobe is bluntly pointed. In other respects, these resemble the typical form and are so classified in Table 1. Another specimen is similar to these but has a flagellar orifice that occupies 45.5 per cent of the flagellar length, and so resembles the atypical form in this respect. This specimen is unclassified in Table 1, and it is the only male observed that is not readily placed.

The copulatory organs of five other species of *Arthrochlamys* have been studied (1). They show differences, usually slight, in the form of the apex of the median lobe and in the form of the flagellum but not in other characters. The organs of one species, *chamaedaphnes* Brown, are inseparable from those of the typical form of *bebbianae*. The organs of eighty specimens of *chamaedaphnes* have been examined. They show moderate variation of a continuous nature like the organs of typical *bebbianae*. The smaller numbers of the other species studied show similar variation. Thus there is no evidence of dimorphism in these other species, and the organs of none of them are characterized more strikingly than are those of the atypical form of *bebbianae*.

I am not aware that dimorphism has been demonstrated previously in copulatory organs. Dobzhansky (4, p. 27) found differences in the shape of the spermatheca in a number of mutants of *Drosophila melanogaster* Meig. Horn (6, 7) suggested that dimorphism may occur in the male copulatory organs of *Pogonostoma elegans hamulipennis* Horn, a cicindelid of Madagascar, and also (6) in those of the lepidopterous genus *Coleophora* Hûbner. Darlington (3) obviously suspected dimorphism such as that described above when he wrote as follows.

"The very fact that striking genitalic characters so often distinguish otherwise similar species of insects suggests that the genitalia are more variable than other parts of the body, for rapid evolution of differences practically requires great individual variation. . . . It seems probable that the genitalia of insects, like their wings, may sometimes undergo mutation and dimorphism, and that two or more distinct forms of genitalia may exist in one species at one time and place. The difference in form of the apex of the phallobase in *Patrobus fossifrons dimorphicus* and *P. f. stygicus* . . . is very suggestive of mutation and dimorphism overlain by a certain amount of other variation."

Processes of dimorphism have been discussed recently by Darlington (2) and by Ford (5).

LITERATURE CITED

1. Brown, W. J. The Canadian species of *Exema* and *Arthrochlamys* (Coleoptera, Chrysomelidae). Canad. Ent., 75:119-131, 5 figs. 1943.
2. Darlington, jr., P. J. Variation and atrophy of flying wings of some carabid beetles. Ann. Ent. Soc. Am., 29:136-179, 3 pls., 2 figs. 1936.
3. Darlington, jr., P. J. The American Patrobini (Coleoptera, Carabidae). Ent. Amer., 18:135-183, 5 pls., 4 figs. 1938.
4. Dobzhansky, Th. Genetics and the origin of species. Columbia Univ. Press, N.Y., XVI+364 pp. 1937.
5. Ford, E. B. Polymorphism and taxonomy. *In* The new systematics, ed. by J. Huxley, pp. 493-513. Clarendon Press. Oxford. 1940.
6. Horn, W. Gibt es bei Insekten echten Dimorphismus der männlichen Kopulations-Organe. Ent. Blätter, 28:66-67, 7 figs. 1932.
7. Horn, W. Revision der Gattung *Pogonostoma* (Col. Cicind.). Arb. Morph. Tax. Ent., 1:7-35, 2 pls., 9 figs. 1934.

CONTRIBUTIONS TO A KNOWLEDGE OF THE LARVAL ELATERIDAE (COLEOPTERA): NO. 3; *AGRIOTES* ESCH. AND *DALOPIUS* ESCH.

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As our knowledge of the larvae increases, the fundamental differences between *Agriotes* Eschscholtz and *Dalopius* Eschscholtz become more apparent. However, the larval characters hitherto used to separate the genera are now known to be quite inadequate. For example, the recently reared larva of *Agriotes criddlei* Van Dyke lacks the commonly accepted "*Agriotes*" characters, but possesses certain "*Dalopius*" features; and the European *Agriotes ustulatus* Schall. (*vide* Znamensky, 1927, fig. 40) combines, in the ninth abdominal segment, the previously accepted primary characters of both genera. These and other findings call for a change in the prevailing generic definitions — in *Agriotes* an even greater change than that proposed by the writer in the second paper of this series (Glen, 1941, p. 58).

While concerned primarily with American species, the present article deals briefly with the relationships of all species of *Agriotes* and *Dalopius* for which the larvae are known. It is believed that this procedure best aids and stimulates progress even though the conclusions presented are suggestive rather than final since only a portion of the recognized species are known in the larval stage and since, in the present instance at least, many of the foreign forms are studied from the literature only.

The writer is indebted to W. J. Brown, Division of Entomology, Ottawa, Ont., for assistance with the nomenclature of the species discussed and for the identification of all reared adults; to W. H. Anderson, United States Bureau of Entomology and Plant Quarantine, Washington, D. C., and E. A. Chapin, United States National Museum, for the loan of larval material; and to K. M. King, Officer in Charge of the Dominion Entomological Laboratory, Saskatoon, Sask., for special assistance in organizing the manuscript.

GENERIC RELATIONSHIPS

Knowledge of the larvae of the subfamily Elaterinae is insufficient at present to serve as a basis for reliable appraisal of the natural affinities of *Agriotes* and *Dalopius*. It is clear, however, that these two genera are closely allied and should not be placed in different tribes as has been done by Leng (1920).

The relationships of *Agriotes* and *Dalopius* are discussed by Van Dyke (1932) and by Brown (1934), both of whom deal only with adult characters and mainly with American species. Van Dyke (op. cit., p. 451) concludes that the genera are separated by a very weak structural character and eventually may have to be united. Brown (op. cit., p. 33) regards them as distinct genera, but states that "*Agriotes* lacks the remarkable homogeneity of *Dalopius* and may be composite."

The two genera are readily distinguished by larval characters. However, *Dalopius* appears to consist of a single extremely uniform group, whereas *Agriotes* comprises several such groups. To unite these genera would only add to the confusing heterogeneity already found in *Agriotes* and would serve no useful purpose. It would be equally extreme to erect a separate genus for each "species group" in "*Agriotes*. Generic revision does not appear to be particularly urgent, but whenever such be undertaken it is suggested that thought be given to restricting *Agriotes* to those "species groups" whose larvae possess the unique eye-like impressions on the ninth abdominal segment. Three such groups are known at present. In the meantime, to facilitate larval identification, it is recommended that *Agriotes* (sens. lat.) be treated as a number of well characterized "species groups" rather than as a single complex unit.

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PROVISIONAL KEY TO SUPRA-SPECIFIC GROUPS IN *AGRIOTES* AND *DALOPIUS*

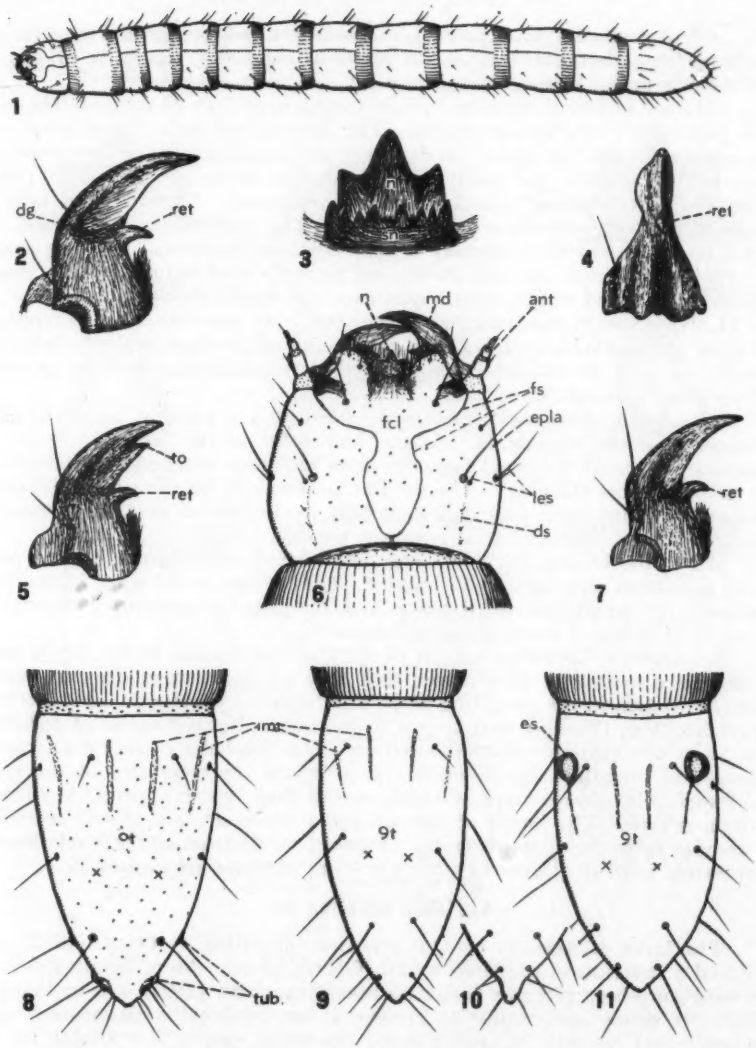
The key which follows includes all larvae of *Agriotes* and *Dalopius* known to the writer, except the Asiatic species, *Agriotes fuscicollis* Miwa, for which information is limited to a small photograph in Kuwayama (1937). The larva of this species apparently bears "eye spots" in the ninth abdominal segment, but other characteristics are unknown. Larvae of several European species, however, were not available for examination and their characteristics are taken solely from the literature.

1. Two conspicuous "eye-like" impressions on ninth abdominal segment (*es*, figs. 11, 12,) 2
   Without such impressions 4
2. Mandible with preapical tooth (*to*, fig. 5) ..... *Agriotes*, the *sputator group*
   American species: *mancus* Say, *pubescens* Mels.
   European species: *sputator* L. (genotype), *lineatus* L., *obscurus* L., and probably also *acuminatus* Steph. and *sordidus* Ill.
   Mandible without preapical tooth (figs. 7, 17) 3
3. Preapical setiferous tubercles on ninth abdominal segment (*tub*, fig. 21); European ..... *Agriotes ustulatus* Schall.
   Without such tubercles ..... *Agriotes*, the *gurgstanuis group*
   European species: *gurgistanus* Fald., *meticulosus* Cand., *pilosellus* Schön.
4. Ninth abdominal segment with preapical setiferous tubercles (*tub*, figs. 8, 19) 5
   Ninth abdominal segment without such tubercles (figs. 9, 10) ..... *Agriotes*, the *limosus group*
   American species: *limosus* Lec., and an unidentified larva from British Columbia.
   European species: *aterrimus* L., tentatively included.
5. Ninth abdominal segment (fig. 8) without central dorso-tergal setae (at positions marked x), with blunt tip, with one or two whorls of minute tubercles (*tub*) near tip ..... *Agriotes*, the *criddlei group*
   American species: *criddlei* Van Dyke.
   European species: *pallidulus* Ill., tentatively included.
   Ninth abdominal segment (fig. 19) with central dorso-tergal setae (*dtc*), with sharp tip, with two or three whorls of tubercles (*tub*) ..... *Dalopius* Esch.
   American species: *mirabilis* Brown, *pallidus* Brown, *parvulus* Brown, *vagus* Brown (?).
   European species: *marginatus* L. (genotype).

Of the key characters employed above, the eye-like impressions on the ninth abdominal segment appear to be of greatest taxonomic significance. This character is found only in certain *Agriotes* species and undoubtedly expresses close genetic relationship. Similarly, the central dorso-tergal setae on the ninth abdominal segment of *Dalopius* larvae seem to be a strong generic character. In contrast, the sharp tip and setiferous tubercles found on the ninth abdominal segment of all *Dalopius* species also occur in the otherwise distinct larvae of *Ischnodes, Adrastus* and *Agriotes ustulatus* Schall. It is suggested, therefore, that such characters are not infallible evidence of close relationship and might even have arisen independently in some instances. The presence of a preapical tooth on the mandible is a valuable "species group" character since it occurs only in the *sputator group*. However, this feature may be obscured in badly worn mandibles.

All the American species included in the key occur in Canada. Their

PLATE V.



LARVAE OF ELATERIDAE

Figs. 1 to 4, 6, 8. *Agriotes criddlei* Van Dyke: 1, well grown larva, dorsal aspect; 2, left mandible, dorsal; 3, nasale and subnasale, ventral; 4, left mandible, medial; 6, head, dorsal; 8, ninth abdominal segment, dorsal.
Figs. 5, 11. *Agriotes mancus* Say: 5, left mandible, dorsal; 11, ninth abdominal segment, dorsal.
Figs. 7, 9. *Agriotes limosus* Lec.: 7, left mandible, dorsal; 9, ninth abdominal segment, dorsal.
Fig. 10. *Agriotes* sp. (from British Columbia): tip of ninth abdominal segment, dorsal.

relationships to other wireworm pests found here are discussed, from the fieldman's point of view, by Glen, King and Arnason (1943).

THE GENUS *AGRIOTES* ESCHSCHOLTZ

All *Agriotes* larvae examined by the writer lack central dorso-tergal setae on the ninth abdominal segment (at positions marked *x*, figs. 8, 9, 11, 21) and thus differ from all known *Dalopius* larvae.

Mature larvae of *Agriotes* vary in length from 9 to 35 mm. and in colour from pale yellow to chestnut brown. The integument lacks conspicuous sculpture (except for the "eye spots" on the ninth abdominal segment of some species), but usually is sparsely and finely punctulate. The nasale (*n*, figs. 3, 6) consists of one tooth, terminating tridentately when uneroded. The antennae bear one "sensory" appendix on the second segment. The mandibles (figs. 2, 5, 7, 17) have a retinaculum (*ret*) and may or may not have additional teeth or prominent expansions. Some *Agriotes* larvae may be recognized at once by the presence of large, pigmented eye-like impressions on the ninth abdominal segment (*es*, figs. 11, 21). Species that lack these "eye spots" are more difficult to recognize; but these all terminate in a blunt or nipple-like point (figs. 8, 9, 10) which, in conjunction with the characters enumerated above, distinguishes them generically from other elaterid larvae.

In defining the genus *Agriotes*, as constituted at present, all of the above characters must be considered. As our knowledge of the larvae increases, the composite nature of the genus becomes more apparent and generic characterization becomes more difficult. The eye-like impressions on the ninth abdominal segment have long been regarded, especially by European workers, as essential *Agriotes* features. This view is no longer tenable.

All of the known *Agriotes* larvae inhabit soil or leaf litter. Some prefer humid situations rich in organic matter. Others are found only in semi-arid locations. All attack cultivated plants and the genus is recognized throughout the world as of major economic importance.

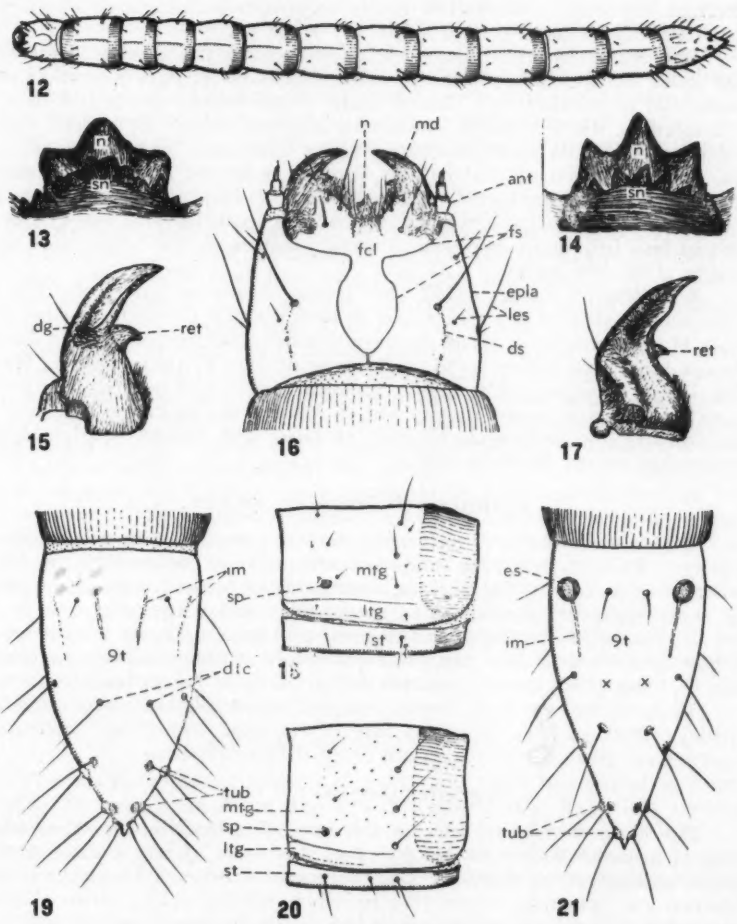
In America, only four species of *Agriotes* are known in the larval stage, but these are so diverse in structure that they represent three distinct "species groups" as shown in the preceding key. The larvae of *mancus* Say, *limosus* Lec., and *criddlei* Van Dyke are well known to the writer, but specimens of *pubescens* Mels. were not available for examination. On the basis of larval characters, *mancus*—and probably also *pubescens*—is a typical representative of the genus *Agriotes* since it belongs unquestionably to the same "species group" as *sputator* L., the genotype. The larvae of *limosus* and *criddlei* are not closely related to one another or to the *sputator group*. Further clarification of their relationship is impossible until the larvae of other species of *Agriotes* are known.

Agriotes mancus Say

The larva of *Agriotes mancus* was first identified by Pettit (1872) who published a description prepared by Dr. George Horn. More detailed descriptions have since been given by Comstock and Slingerland (1891) and by Hawkins (1936). It seems inadvisable to present a further lengthy description until adequate larval material of closely allied American species is available for the essential detailed comparison.

The larvae are pale yellow and attain a length of 19 to 23 mm. when mature. In comparison with other American species, they are readily recognized by the ninth abdominal segment (fig. 11) which is blunt at the tip, lacks tubercles, and has two conspicuous eye-like impressions (*es*) dorsally near the front margin. The mandible (fig. 5) bears a preapical tooth (*to*) which is sharp and prominent when uneroded. Other diagnostic characters are: ninth abdominal segment about one and one-half times as long as greatest width and nearly twice as long as its width at base; distance from tip of ninth abdominal

PLATE VI.



LARVAE OF ELATERIDAE

Figs. 12, 13, 15, 16, 18, 19. *Dalopius pallidus* Brown: 12, well grown larva (fully distended), dorsal aspect; 13, nasale and subnasale (somewhat eroded, but showing maximum number of denticles), ventral; 15, left mandible, dorsal; 16, head, dorsal; 18, fifth abdominal segment, lateral; 19, ninth abdominal segment, dorsal.

Fig. 14. *Dalopius mirabilis* Brown: nasale and subnasale (showing the minimum number of denticles observed in a mature *Dalopius* larva), ventral.

Figs. 17, 21. *Agriotes ustulatus* Schall. (redrawn from Znamensky, 1927): 17, left mandible (stated to be uneroded), dorsal; 21, ninth abdominal segment, dorsal.

Fig. 20. *Agriotes criddlei* Van Dyke: fifth abdominal segment, lateral.

segment to pleural area approximates eleven-twentieths of total length of segment; fronto-clypeal area bluntly pointed posteriorly; subnasale bearing eight to ten denticles; each gena with five latero-epicranial setae arranged as two pairs with an unpaired hair further dorsad; and each mediotergite of first eight abdominal segments with shallow linear longitudinal impression laterally, but without definite transverse impression.

This species occurs from the Atlantic Coast as far west as Manitoba and as far south as Missouri. It is the most important wireworm pest in eastern Canada and in northeastern United States. Infestations are found in a wide variety of soils, but the larvae are usually most abundant in "muck" soils and other poorly drained land, especially where grass has been grown in recent years. The preferred natural habitat appears to be the marshes and meadowlands of the eastern hardwood forest. Rawlins (1940) gives the normal larval life as three or four years with a few individuals requiring five years. Pupation occurs in late July or in August and transformation to the beetle stage is completed in about two weeks.

According to Forbes (1892) the larvae of *mancus* and *pubescens* Mels. are inseparable structurally and occur in almost equal numbers in Illinois corn fields. However, *mancus* seems to have a wider distribution and to be much more common than *pubescens* in cropped fields since Gorham (1924), Hawkins (1928, 1936), Rawlins (1934, 1940), Thomas (1941) and others make no reference to *pubescens* as a pest species and since *mancus*-like larvae collected from farm land in New Brunswick, Quebec, Ontario, and Manitoba all matured to *mancus* when reared by the writer.

Agriotes pubescens Melsheimer

Specimens of *Agriotes pubescens* were not available for examination by the writer. The only reference to the larvae is made by Forbes (1892, p. 34) who is quoted here in full: "This species, closely related to the foregoing [*A. mancus* Say], is not separable from it in the larval stage, and as the two occur in about equal abundance in corn fields [in Illinois] and have a similar life history, they may best be treated—at least until more is known of them—as a single economic species." Leng (1920, p. 172) records *pubescens* from Pennsylvania and west as far as Manitoba and the Lake Superior region of Canada and the United States. Blatchley (1910, p. 741) lists it as rare in Indiana. Additional notes on the occurrence are given in the paragraph immediately preceding.

Agriotes limosus LeConte

The larva of *Agriotes limosus* was first identified by the writer who described it in detail in the second paper of this series (Glen, 1941). Only the principal distinguishing characaters are enumerated below. The larva is yellowish brown and measures up to 19 mm. when mature. The ninth abdominal segment (fig. 9) is blunt at the tip and lacks both the "eye spots" of *mancus* and the setiferous tubercles of *criddlei*. The mandible (fig. 7) is without a preapical tooth or any conspicuous dorsal expansion of the anterior inner surface. Other important features are: ninth abdominal segment about twice as long as its greatest width and slightly more than twice as long as its width at base; distance from tip of ninth abdominal segment to pleural area approximates five-sevenths of total length of segment; fronto-clypeal area broadly rounded or truncate posteriorly; subnasale bearing twelve to fourteen denticles; each gena with five latero-epicranial setae usually arranged as two pairs with an unpaired hair further dorsad; and each mediotergite of first eight abdominal segments with shallow linear longitudinal impression laterally, but without definite transverse impression. The larva of *limosus* is readily distinguished from a related unidentified larva and from the European *aterrimus* L., both of which terminate in a nipple-like or wart-like point.

This northern species occurs from Newfoundland to the Rocky Mountains. It inhabits the soil of the northern coniferous forest and its various successional stages, particularly the aspen poplar. The larvae appear to prefer moist, but well drained, situations such as damp leaf litter overlying sand or the grey podsolized soil in field depressions that are well drained because of a sandy subsoil. When such areas are put under cultivation the species persists in small numbers for many years and is believed to be of minor economic importance (King, 1928, p. 705, 'a species of Agriotini?'). Nothing is known of the duration of the larval period. The only larvae that have been reared to maturity were collected from park and forest areas in northern Saskatchewan. These pupated during the last half of July and the pupae transformed to adults after about two weeks.

Agriotes sp.

In structure this larva appears to be almost identical to the European *Agriotes aterrimus* L. (vide Beling 1883, pp. 135-138; 1884, pp. 199-200) from which it is most readily separated on the basis of distribution. It is also very similar to the American *A. limosus* Lec., differing mainly in the termination of the ninth abdominal segment (figs. 9, 10).

Mature larvae were not available, but the specimens examined were robust, measuring up to 17 mm. by 1.75 mm. although not fully distended; full grown larvae probably would exceed 20 mm. in length and might even attain 25 mm., as recorded for *aterrimus*. The colour is brown to yellowish brown, usually slightly darker than in *limosus*. The ninth abdominal segment, which is twice as long as wide, terminates in a nipple-like tip (fig. 10) and the distance from the tip of the segment to the pleural area approximates two-thirds of the total length of the segment. The fronto-clypeal area usually is broadly rounded posteriorly. Each stipes is at least twice as wide anteriorly as posteriorly and has five setae on antero-latero-ventral aspect; proxistipes and dististipes distinctly separated. The mandibles and general sculptural and setal characters are as in *limosus*.

These specimens were collected at Pemberton, British Columbia, by R. Glendenning of the Dominion Entomological Laboratory, Agassiz, B. C.. It is believed that the larvae normally inhabit forest soil, as do *limosus* and *aterrimus*, but the only information available is that these specimens were taken "on decaying turnips near the forest edge."

Agriotes criddlei Van Dyke

The larva of *Agriotes criddlei* is readily identified by its small size (rarely exceeding 10 mm.), the ninth abdominal segment (fig. 8) which terminates bluntly but bears minute setiferous tubercles (*tub*) and lacks "eye spots", and by the mandibles (figs. 2, 4) which lack a preapical tooth but have a prominent dorsal expansion of the anterior inner surface. A detailed description is given on page 83.

The known range of this species is from Aweme, Manitoba, to interior British Columbia and south to Colorado. The most northern record is from Saskatoon, Saskatchewan. It is a typical open prairie species and an important crop pest in southern Alberta (Strickland, 1926, p. 4, 'species of *Agriotes*') and southwestern Saskatchewan (King, 1928, p. 705, 'Agriotini? - - - a rather small species'). The larvae occur only in the brown soil zone which is relatively poor in organic matter. They are found most frequently in fields of loam soils with considerable clay in the subsoil. However, specimens have been taken in soils ranging in surface texture from fine sandy loam to clay. Larvae have been found in irrigated land in Alberta, but never in abundance. The duration of the larval period is unknown, but, judging from the size of specimens found together, it must exceed one year and probably averages about three years. Larvae which were reared to maturity pupated in the laboratory during the first week of August, the adults appearing in a week to ten days.

EUROPEAN SPECIES OF *AGRIOTES*

The characteristics of the larvae of eleven European species of *Agriotes* have been studied from the literature, particularly from the works of Beling (1883, 1884), Henriksen (1911), Horst (1922), Rambousek (1927), Roberts (1922), Subklew (1934), and Znamensky (1927). For some of these the descriptions are quite incomplete and it was found necessary in preparing "species groups" to make some use of inference and conjecture. Larval material of *A. sputator, A. lineatus, A. obscurus, A. gurgistanus,* and *A. meticulosus* was kindly loaned to the writer by the United States National Museum. These are the only European species of which material has been available for examination.

The *sputator group* is well known throughout Europe and until recently the larval characteristics of this group were regarded widely as definitive of all *Agriotes*. The larvae of *sputator* L., *lineatus* L., and *obscurus* L. have been adequately described. From these and the American species, *A. mancus* Say, the primary characteristics of the group have been determined as follows: ninth abdominal segment (fig. 11) with two large eye-like impressions (*es*) dorsally near anterior margin, tip blunt or short and sharp, and without preapical setiferous tubercles; mandibles (fig. 5) with retinaculum (*ret*) and preapical tooth (*to*); larva 17 to 25 mm. in length when mature; and pale yellow to brownish yellow in colour. The provisional inclusion in this group of *A. acuminatus* Steph. (= *sobrinus* Kies.) is based upon the work of Roberts (1922, pp. 315-316) who studied the first instar larva and concluded that it closely resembled *sputator* and *obscurus* and possessed a preapical tooth (="subapical tooth" of Roberts) on the mandible. However, the existence of this preapical tooth might be open to question since Roberts remarked upon its unusual form as "long and narrow, extending as a kind of flange from the retinaculum nearly to the apex" and since his accompanying illustrations (p. 309, text fig. 1 (a), and 1 (d)) clearly show the mandibles of the first instar larvae of *sputator* and *acuminatus* to be of quite different types. When later instars are available for examination, the affinities of *acuminatus* may be found to be nearer the *gurgistanus group*. The larva of *sordidus* Ill. bears at least general resemblance to *sputator* and since observant writers have not reported fundamental differences it is assumed that the species possesses the main characteristics of this group.

The *gurgistanus group* includes the European species *gurgistanus* Fald., *meticulosus* Cand., and *pilosellus* Schon. (= *elongatus* Marsh.). No American representatives are known. This group is closely related to the *sputator group* as revealed by these primary characteristics: ninth abdominal segment with two large eye-like impressions dorsally (as in fig. 11), tip blunt, or short and sharp, and without preapical setiferous tubercles; mandibles (as in fig. 7) with retinaculum, but lacking preapical tooth; larvae 25 to 35 mm. in length when full grown; and yellow to chestnut brown in colour. These primary group characters are believed to be reliably established. However, the species grouped together here might eventually be separated into two closely related "species groups" since other diversities of structure were noted. In his illustrated key, Znamensky (1927) characterizes *gurgistanus* and *pilosellus* (= *elongatus* Marsh). Henriksen (1911) also briefly describes *pilosellus* under the name "*pilosus* F.". Brief reference to *meticulosus* is made by Ghilarov (1937).

Agriotes ustulatus Schaller is of unusual taxonomic interest since, on the basis of previously accepted generic characters, it appears to bridge the gap between the genotypes *Agriotes sputator* L. and *Dalopius marginatus* L. As described and figured by Znamensky (1927, fig. 40) the larva combines in the ninth abdominal segment (fig. 21) the large eye-like impressions (*es*), found only in certain *Agriotes*, with the commonly accepted characters of *Dalopius*, namely, sharp tip and whorls of setiferous tubercles (*tub*). The mandibles (fig. 17) have a retinaculum (*ret*), lack a preapical tooth, and have the anterior inner margin strongly expanded dorsally. Mature larvae measure up to 20 mm. in

length and are brownish yellow in colour. This description is in agreement with Rambousek (1927, p. 5), but differs from that of Henriksen (1911, p. 246) who does not mention the presence of tubercles. This may mean that the larvae of different species are confused under the name *ustulatus* Schall. However, the fact remains that Znamensky described and figured the larva of some species of *Agriotes* which clearly possessed the above characteristics. It is the writer's opinion that the larva so described belongs unquestionably to the genus *Agriotes,* by virtue of the eye-like impressions. Its relationship to *Dalopius,* however, may be much more remote since the larva lacks central dorso-tergal setae on the ninth abdominal segment. Such setae are much more definitive of the genus *Dalopius* than are the tubercles and sharp tip of the ninth abdominal segment – characters that are common to several genera. Further critical study of both the larvae and adults of this species is recommended. Until the question of identification is fully clarified, it seems best to designate it as *A. ustulatus* Schall.

Agriotes aterrimus Linnaeus has been carefully described by Beling (1883, pp. 135-138; 1884, pp. 199-200). However this larva has received little attention subsequently in spite of the fact that it lacks the generic characters of *Agriotes* as commonly defined by the leading European writers. Its principal characteristics are: ninth abdominal segment without eye-like impressions, without preapical setiferous tubercles, and terminating in a thick wart-like tip; mandibles with retinaculum, but without preapical tooth; larva robust, up to 25 mm. in length when mature; and yellowish brown in colour with the ninth abdominal segment somewhat darker. This larva obviously is more closely related to the American *limosus* Lec. and the unidentified larva from British Columbia than to any other known larvae, hence it is tentatively placed in the *limosus group.* All of these species inhabit forest soil, but *aterrimus* has also been recorded from decaying wood.

Agriotes pallidulus Illiger is another European wireworm which lacks the previously accepted characteristics of *Agriotes.* According to Beling (1883, pp. 142-143; 1884, p. 198) the ninth abdominal segment is without eye-like impressions, has small preapical setiferous tubercles, and terminates in a short, conical point; mandibles with retinaculum, but without preapical tooth; larva slender, up to 9 mm. in length and extraordinarily active; and of intense yellow colour. These structural characters, together with an apparent preference for cultivated land, suggest that its affinities probably are with the American species *A. criddlei* Van Dyke. The larvae of *pallidulus* are reported to pupate in late May or in early June, which is considerably earlier than for any other known *Agriotes* species.

THE GENUS *DALOPIUS* ESCHSCHOLTZ

Dalopius larvae are pale brown and rarely exceed 15 mm. in length. They are sparsely and finely punctulate, but without conspicuous pits or other prominent sculpture. The ninth abdominal segment (fig. 19) is nearly twice as long as wide, has two central dorso-tergal setae (*dtc*), has a sharp tip, lacks the "eye spots" found in certain *Agriotes* larvae, and bears two or three whorls of setiferous tubercles (*tub*). The nasale (*n*, figs. 13, 14, 16) consists of one tooth, terminating tridentately when uneroded. The antennae bear one "sensory" appendix on the second segment. The mandibles (fig. 15) have a retinaculum (*ret*) but lack other teeth or prominent expansions.

All of the above characters must be considered in defining the genus *Dalopius.* However, the presence of a central pair of setae on the dorsum of the ninth abdominal segment (*dtc*, fig. 19) appears to be of primary significance. The only instance in which corresponding setae were observed in closely related larvae was on two specimens in the United States National Museum which were provisionally identified as *"Betarmon bigeminatus* Rand." (=*Agriotella bigeminata*). Hitherto, the accepted primary characteristics of *Dalopius* lar-

vae were the sharp tip and whorls of preapical setiferous tubercles on the ninth abdominal segment. These are excellent supplementary characters, but taken alone do not distinguish the genus since such features occur in the larvae of several other genera.

All known *Dalopius* larvae inhabit soil and decomposing leaf litter. They prefer rich, humid situations such as river flats, wooded ravines, and the marshes and meadows of parkland. When such areas are put under cultivation the larvae damage the crops and apparently continue as pests for many years. In the Prairie Provinces infestations of *Dalopius* are confined to the black soil zone. Larvae have never been collected from typical open prairie country, even where irrigation has been practiced for many years.

In America, the larvae of *mirabilis* Brown, *pallidus* Brown, *parvulus* Brown, and *vagus* Brown (?) have been reared to maturity. Based upon a study of the adults, Brown (1934) placed these four species in three different "species groups." Corresponding distinction has not been found in the larvae which are so similar that reliable specific characters have not been discovered. The information secured to date suggests that ecological characters may provide a basis for larval identification, but insufficient data are at hand to make this possible at present. Together with the European *Dalopius marginatus* L., the genotype, they form a very uniform group.

Dalopius mirabilis Brown

This species is now believed to be confined to the Great Plains Region*. Larvae have been reared to maturity from Findlay, Manitoba, and from Buchanan, Mozart, Rhein, Turtleford, and Wadena, Saskatchewan. At Mozart, larvae were found in considerable numbers under horse and cow manure in a native grass pasture bordering Quill Lake. All collections of *mirabilis* have been taken from soils of medium or light texture (Oxbow and Yorkton loams and light loams and Meota fine sandy loam) and generally from low-lying areas where alkali was known or suspected to be present. This species causes severe damage to cereals, especially in land recently put under cultivation. Larvae which were reared pupated between July 8 and August 15 and the beetles appeared after about two weeks.

Full grown larvae of *mirabilis* sometimes are slightly longer than those of the other species examined, measuring up to 16.5 mm. when fully distended but rarely exceeding 15 mm.

Dalopius pallidus Brown

This common species is known from New Brunswick to Alberta. Larvae have been reared to maturity from Souris, Manitoba, and from Saskatoon and Swift Current, Saskatchewan. The species is reported to have damaged cereals at Wetaskewin, Alberta, and it is a common pest of truck crops in the muck soils of Ontario and southern Quebec. However, in Saskatchewan, larvae have never been found in cultivated land, but only in decomposing leaf litter in moist, shaded locations. It is concluded, therefore, that this species requires an exceptionally rich and moist habitat and probably tolerates a considerable variation in pH, especially toward the acid side. Reared specimens pupated during the last half of July and the beetles emerged after ten days to two weeks.

Full grown larvae of *pallidus* rarely exceed 14 mm. in length, but distended specimens have measured 15.5 mm. For a detailed description see page 85.

Dalopius parvulus Brown

D. parvulus is relatively rare and apparently is confined to Manitoba and Saskatchewan (Brown, 1934, p. 72). Larvae have been reared to maturity from

*Information received in a personal communication, October 29, 1943, from Mr. W. J. Brown, Division of Entomology, Ottawa.

St. Gregor, Marysburg, and Wadena, Sask. In each instance the species was taken from soil of medium texture (Yorkton loam) and the presence of alkali was not detected. The larvae have been known to damage cereals. Specimens which were reared pupated during the last half of July and the first half of August and the beetles emerged after ten days to two weeks.

This species is somewhat smaller than *mirabilis* and *pallidus*, the larvae rarely exceeding 13.5 mm. in length although fully distended specimens have measured nearly 15 mm. The larva has been described briefly (Glen, 1931).

Dalopius vagus Brown (?)

Brown (1934, p. 36) gives the distribution of *vagus* as from Manitoba to New Brunswick and West Virginia. The three specimens examined in the present study were collected by R. F. Morris from leaf litter under spruce in Sunbury and York Counties, N.B. One specimen was reared to maturity and the adult (♀) was identified by W. J. Brown as "*Dalopius* sp., probably *vagus* Brown". A predacious habit is suggested since Morris found, during his rearing work, that the larvae fed to some extent upon the cocoons of the European spruce sawfly, *Gilpinia hercyniae* (Htg.).

The largest larva examined measured 12 mm. in length, but judging by the size of the adults mature larvae should measure up to 15 mm. when fully distended. In both of the whole larvae examined, the sides of the ninth abdominal segment taper right from the base of the segment. In other *Dalopius* larvae the proximal one-fourth to one-third of this segment is usually sub-cylindrical with only a very few individuals tapering in the fashion observed in *vagus*. The larvae of *vagus* possess only one seta on each side of the prosternum and in general lack most of the minute setae commonly found on the mediotergites of other species. Additional material must be examined before concluding that these minor differences are constant and consequently of specific significance.

NEW DESCRIPTIONS

As a basis for future comparison, the larvae of *Agriotes criddlei* and *Dalopius pallidus* are described here in considerable detail. The distribution and habits of these species are discussed on pages 79 and 82, respectively.

Agriotes criddlei Van Dyke
(Figures 1 to 4, 6, 8, 20)

The description which follows is based upon an examination of the last larval exuviae of four reared specimens from Warner (3) and Macleod (1), Alberta; and thirty-four larvae from the following points: Admiral (2), and Glasnevin (2), Saskatchewan; and Bradshaw (2), Glenwood (6), High River (1), Macleod (5), Manyberries (2), New Dayton (7), Pincher (2), Taber (2), and Warner (3), Alberta.

Mature larvae (fig. 1) rarely exceed 10 mm. in length, but have measured 13 mm. when fully distended; greatest breadth up to 1.0 mm., usually across thorax and first half of abdomen. Body cylindrical, sides subparallel, pleural membranes small and inconspicuous. Pale brown or yellowish brown in colour, near "buckthorn brown" as in Ridgway (1912). Dorsum slightly rugose, punctulate, punctures small and shallow.

Head (fig. 6) subquadrangular, somewhat flattened above and below, sides arcuate. *Fronto-clypeal region* (*fcl*) sparsely and finely punctulate, frontal sutures (*fs*) distinct; posterior portion terminating just before reaching base of head: broadly rounded posteriorly. *Nasale* (*n*) of one tooth, but with tip tridentate when uneroded; median denticle largest. *Subnasale* (*sn*, fig. 3) consisting of transverse ridge, serrate when uneroded, with about eight subequal, short, sharp, forward-projecting denticles, sometimes also two or three minute denticles. *Epicranial plates* (*epla*, fig. 6) sparsely and finely punctulate; dorsal sulci (*ds*) very shallow, indefinite, each with a row of four setae, the most an-

terior hair being very long and just antero-mediad to the most dorsal latero-epicranial seta (*les*), remaining setae minute and subequally spaced; ventral sulci conspicuous, each with two prominent setae and a few minute hairs; each gena with four latero-epicranial setae (*les*) arranged as a central pair with an unpaired hair further ventrad and an unpaired hair further dorsad near the dorsal sulcus; eye spot black, ovate or circular, surrounded by two to four setae, only two being prominent. *Postgenal areas* meet mesally; each with one minute seta in central area. *Gula* lacking. *Antennae* (*ant*) with first segment slightly longer than wide, at least twice as long and nearly twice as wide as second segment; second segment as wide as long, bearing one well developed conical "sensory" appendix just ventrad to base of third segment; third segment narrow but as long as second segment. *Mandibles* (figs. 2, 4) with prominent retinaculum (*ret*); distal half with shallow dorsal groove (*dg*) and with dorsal margin of inner face expanded and strongly convex dorsally. *Ventral mouthparts* exclusive of palpi about two-thirds as long as sides of epicranium. *Cardines* well developed, medial margins almost touching. *Stipes* large, subrectangular, posterior end about two-thirds as wide as anterior end; four setae on antero-latero-ventral aspect; proxistipes and dististipes very indistinctly separated. *Postmentum* subrectangular, with one prominent seta in each corner. *Labial palpi* with basal joint bearing two or three fine setae.

Prothorax about as long as mesothorax and metathorax combined. *Tergites* minutely punctulate; without "impressions"; anteriorly (on each side of median suture) usually with five to seven setae in transverse row, three being prominent; posteriorly with three prominent unpaired setae in transverse row, sometimes one or two minute hairs further posterad. No distinct laterotergites, but faint line suggests internal ridge at point of fusion of medial and lateral sclerites. *Prosternum* shield-shaped; consisting of one sclerite, striate on antero-lateral aspects and bearing two prominent setae along each side.

Mesothorax and *metathorax* each much wider than long. *Mediotergites* minutely punctulate; without impressions; anteriorly with transverse row of two short setae and sometimes one or two minute hairs; posteriorly with transverse row of two prominent setae and sometimes one minute hair near the more lateral of these; glabrous elsewhere. Episternum subtriangular, without spine-like setae. *Spiracles* bifore, slightly larger than spiracles in abdominal segments.

Legs well developed. *Coxa* subcylindrical, excavate on outer surface; bearing up to sixteen spine-like setae on anterior surface. Other segments well supplied with spine-like and other setae.

First to eighth abdominal segments (fig. 20) subequal. *Mediotergites* (*mtg*) punctulate, punctures small and shallow, like pin pricks or slightly larger; impressions wanting or very indistinct; anteriorly with three short unpaired setae; posteriorly with three prominent unpaired setae and sometimes one minute hair just caudad to each of these. *Spiracles* (*sp*) small, in antero-lateral part of mediotergite. *Laterotergites* (*ltg*) narrow, subrectangular, slightly narrower anteriorly, extending length of segment and joined posteriorly to mediotergite; without setae. *Pleurites* lacking. Sternum of one piece; large, subquadrate, with longitudinally striate posterior margin; sparsely punctulate; without definite impressions; usually bearing about six conspicuous setae, three along each lateral margin, sometimes also one or two minute hairs.

Ninth abdominal segment (fig. 8) subconical; at least one and one-half times as long as wide and sometimes nearly twice as long as wide; nearly as wide and about one and one-half times as long as eighth abdominal segment; posterior half tapering to a blunt point. *Tergite* (*9t*) shallowly and irregularly wrinkled; punctulate, with punctation somewhat denser than in preceding segment; four faint longitudinal impressions (*im*) near base; usually about six small or minute setiferous tubercles (*tub*) arranged in irregular whorl near tip of segment; in large specimens a minute tubercle may appear around the base of each hair

in the adjacent whorl situated slightly further forward; while in young larvae all tubercles are indistinct or even lacking. *Pleural area* faintly striate. Distance between tip of segment and pleural area approximates five-eights to five-sevenths of total length of segment. *Sternum* of one piece, bearing six setae in irregular transverse row in front of tenth abdominal segment.

Tenth abdominal segment short, tubular, bearing a whorl of ten fine hairs; without anal armature; anal aperture linear and median.

Dalopius pallidus Brown
(Figs. 12, 13, 15, 16, 18, 19)

Since a detailed study has failed to reveal reliable distinguishing structural characters for the larvae of *Dalopius pallidus, D. mirabilis, D. parvulus,* and *D. vagus* (?), the description which follows would apply equally to each of these species. The material examined included the last larval exuviae of five reared specimens of *pallidus* collected at Saskatoon (4), Saskatchewan, and Souris (1), Manitoba, and nine larvae from Saskatoon taken in the same location as those which were reared to maturity.

Mature larvae (fig. 12) rarely exceed 14 mm. in length, but fully distended specimens measure up to 15.5 mm.; greatest breadth 1.1 mm., usually across the third or fourth abdominal segment. Body cylindrical, sides subparallel, pleural membranes small except in prepupal larvae when lateral membranes become conspicuous. Pale brown or yellowish brown in colour. Dorsum slightly rugose, sparsely punctulate, punctures small, shallow, and inconspicuous.

Head (fig. 16) subquadrangular, flattened above and below, sides weakly arcuate. *Fronto-clypeal region* (*fcl*) with distinct frontal sutures (*fs*); posterior portion terminating just before reaching base of head; broadly rounded or bluntly pointed posteriorly. *Nasale* (*n*) of one tooth but with tip tridentate when uneroded; median denticle largest. *Subnasale* (*sn,* fig. 13) consisting of transverse ridge, anteriorly convex, serrate when uneroded, with seven to twelve (usually about eight) subequal, short, sharp, forward-projecting denticles. *Epicranial plates* (*epla,* fig. 16) with indistinct dorsal sulci (*ds*) bearing four setae, the most anterior hair large and situated antero-mediad to the most dorsal of the latero-epicranial setae (*les*), remaining setae minute and subequally spaced; ventral sulci conspicuous, each with two prominent setae and a few small or minute hairs; each gena with five latero-epicranial setae (*les*) arranged as two pairs (one of each pair being short) and an unpaired hair further dorsad near dorsal sulcus; eye spot black, ovate or circular, surrounded by three (rarely four) setae, usually only two being prominent. *Postgenal areas* meet mesally; each with one minute seta in central area. *Gula* lacking. *Antennae* (*ant*) with first segment largest, slightly longer than wide; second segment narrower and about one-half as long as first segment, with well developed "sensory" appendix situated ventrad to base of third segment, third segment narrow, subcylindrical, as long as second segment, but less than one-half as wide. *Mandibles* (fig. 15) with prominent retinaculum (*ret*), distal half with shallow dorsal groove (*dg*) and dorsal margin of inner face moderately convex dorsally. *Ventral mouthparts* exclusive of palpi at least two-thirds as long as sides of epicranium. *Cardines* well developed, medial margins almost touching. *Stipes* large, subrectangular, posterior end less than one-half as wide as anterior end; three or four setae on antero-latero-ventral aspect; proxistipes and dististipes distinct. *Postmentum* subrectangular with one prominent seta in each corner. *Labial palpi* with basal joint bearing one or two fine setae on ventral surface.

Prothorax about four-fifths as long as mesothorax and metathorax combined. *Tergites* minutely punctulate; without impressions; anteriorly (on each side of median suture) usually with seven to ten setae in irregular transverse row, one being noticeably closer than others to mid-dorsal suture; posteriorly with four or five (rarely six) setae in transverse row, only three being prominent. No distinct laterotergites, but faint line suggests internal ridge at point of

fusion of medial and lateral sclerites. *Prosternum shield-shaped;* consisting of one sclerite, striate on antero-lateral aspects and bearing two setae along each side, the most anterior being larger.

Mesothorax and *metathorax* each much wider than long. *Mediotergites* with scattered minute punctures; without impressions; anteriorly with transverse row of three short setae, subequally spaced, sometimes also one minute seta; posteriorly with transverse row of three to five setae, only two being prominent, usually arranged as two pairs with one long and one minute hair in each pair; glabrous elsewhere except for minute setae in some punctures. *Episternum* subtriangular, without spine-like setae. *Spiracles* bifore, at least one and one-half times as long as spiracles in abdominal segments.

Legs well developed. *Coxa* subcylindrical, excavate on outer surface; bearing up to fifteen spine-like setae on anterior surface. Other segments well supplied with spine-like and finer setae.

First to eighth abdominal segments (fig. 18) subequal. *Mediotergites* (*mtg*) without well defined impressions; anteriorly with four setae, three short but prominent and subequally spaced, the fourth very small and situated anterad to the middle one of the larger hairs; posteriorly with three long setae and usually two or three short or minute hairs which sometimes are lacking. *Spiracles* (*sp*) small, in antero-lateral part of mediotergite. *Laterotergites* (*ltg*) narrow, subrectangular, slightly narrower anteriorly, extending length of segment and closely applied to mediotergites; with one small seta near each end. *Pleurites* lacking. *Sternum* (*st*) of one piece, large, subquadrate, with longitudinally striate posterior margin; without definte impressions; usually bearing ten to fourteen setae (eight to ten readily observable) mostly along lateral margins.

Ninth abdominal segment (fig. 19) subconical; about twice as long as width at base; slightly narrower and slightly longer than eighth abdominal segment; posterior half tapering to a sharp point; sides sometimes slightly concave in region between two main whorls of tubercles. *Tergite* (*9t*) shallowly and irregularly wrinkled; four faint longitudinal impressions (*im*) near base, lateral pair sometimes very indistinct or lacking; two irregular whorls of small setiferous tubercles (*tub*) in posterior one-fourth of segment, the most posterior whorl consisting of six tubercles, the other of eight; on some specimens the setae still further anterad issue from minute tubercles thus forming a third whorl. *Pleural area* faintly striate. Distance between tip of segment and pleural area approximates four-sevenths of total length of segment. *Sternum* of one piece, bearing up to fourteen setae in irregular transverse row in front of tenth abdominal segment, usually about eight are readily observable, others inconspicuous.

Tenth abdominal segment short, tubular, bearing a whorl of ten fine setae; without anal armature; anal aperture linear and median.

REFERENCES

Beling, Th. 1883-84. Beitrag zur Metamorphose der Käferfamilie der Elateriden: Deutsche ent. Zeit. Berlin, Bd. 27 (1883), pp. 129-144, 257-304; Bd. 28 (1884), pp. 177-216.

Blatchley, W. S. 1910. The Coleoptera of Indiana: Bull. 1, Ind. Dept. Geol. and N. H., Nature Pub. Co. Indianapolis, Ind.

Brown, W. J. 1934. The American species of *Dalopius* Esch. (Elateridae, Coleop.): Can. Ent. vol. 66, pp. 30-39, 66-72, 87-96, 102-110.

Comstock, J. H., and Slingerland, M. V. 1891. Wireworms: Bull. 33, Ent. Div. Cornell Agr. Expt. Sta., N. Y., pp. 192-275, illus.

Forbes, S. A. 1892. Wireworms: *In* Eighteenth report of the state entomologist on the noxious and beneficial insects of the state of Illinois for the year 1891-1892. Ill. State Jour. Co., 1920, pp. 24-44, illus. (Reprinted by authority of the State of Ill., Springfield, Ill., 1920).

Ghilarov, M. S. 1937. The fauna of injurious soil insects of arable land: Bull. Ent. Res. vol. 28, pt. 4, pp. 633-637.

Glen, R. 1931. The external morphology and the characters separating the elaterid larvae of Saskatchewan; a preliminary study: Report to Can. Div. Ent., and to Univ. Sask. (M.Sc. Thesis), 118 pp. (typed), illus., May 1931.

————1941. Contributions to the morphology of the larval Elateridae (Coleoptera); No. 2. *Agriotes limosus* LeConte: Can. Ent. vol. 73, pp. 57-62, illus.

Glen, R., King, K. M., and Arnason, A. P. 1943. The identification of wireworms of economic importance in Canada: Can. Jour. Res., vol. 21, no. 11, pp. 358-387, illus.
Gorham, R. P. 1924. Notes on *Agriotes mancus* Say at Dartmouth, N.S.: Proc. Acadian Ent. Soc. 1923, no. 9, pp. 69-72, Truro.
Hawkins, J. H. 1928. Wireworms affecting Maine Agriculture: Me. Agr. Expt. Sta. Bull. 343, 20 pp.
————1936. The bionomics and control of wireworms in Maine: Me. Agr. Expt. Sta. Bull. 381, 146 pp., illus.
Henriksen, K. L. 1911. Oversigt over de danske Elateride larver (Danish with English summary): Entom. Medd. vol. 4, pp. 225-331, illus.
Horst, A. 1922. Zur Kenntnis der Biologie und Morphologie einiger Elateriden und ihrer Larven (Insbesondere Untersuchungen uber *Agriotes obscurus* L.): Arch. Naturgesch., vol. 88, pp. 1-90, illus.
King, K. M. 1928. Economic importance of wireworms and false wireworms in Saskatchewan: Sci. Agric. vol. 8, no. 11, pp. 693-706.
Kuwayama, S. 1937. Chafers or scarabaeid beetles and their relation to agriculture [In Japanese]: Hokkaido Agric. Expt. Sta., Bull. No. 61, 73 pp., illus.
Leng, C. W. 1920. Catalogue of the Coleoptera of America, north of Mexico: John D. Sherman, Jr., Mt. Vernon, N. Y.
Pettit, J. 1872. Description of the wheat wireworm *Agriotes mancus* Say: Can. Ent. vol. 4, pp. 3-6, illus.
Rawlins, W. A. 1934. Experimental studies on the wheat wireworm, *Agriotes mancus* Say: Jour. Econ. Ent. vol. 27, no. 2, pp. 308-314.
———— 1940. Biology and control of the wheat wireworm, *Agriotes mancus* Say: Cornell Univ. Agric. Expt. Sta. Bull. 738, 30 pp., illus., Ithaca, N. Y.
Ridgway, R. 1912. Color standards and nomenclature: Pub. by the author, Wash., D. C.
Roberts, A. W. R. 1922. On the life-history of "wireworms" of the genus *Agriotes* Esch., with some notes on that of *Athous haemorrhoidalis* F., Part III: Ann. App. Biol. vol. 9, nos. 3 and 4, pp. 306-324, illus.
Strickland, E. H. 1926. Wireworms of Alberta: Univ. of Alta. Res. Bull. No. 2, 17 pp., illus.
Subklew, W. 1934. *Agriotes lineatus* L. und *Agriotes obscurus* L. (ein Beitrag zu ihrer Morphologie und Biologie): Zeit. Angew. Ent. Bd. 21, pp. 96-122, illus.
Thomas, C. A. 1941. The Elateridae of Pennsylvania: Jour. N. Y. Ent. Soc. vol. 49, pp. 233-263.
Van Dyke, E. C. 1932. Miscellaneous studies in the Elateridae and related families of Coleoptera: Proc. Cal. Acad. Sci., 4th Ser., vol. 20, no. 9, pp. 291-465.
Znamensky, A. V. 1927. Instructions for carrying out observations on the entomofauna of the soil [In Russian]: Trudui Poltavsk. S-Kh. Opuitn. Stantz. [Trans. Poltava Agric. Expt. Sta.] no. 51, Ent. Div. no. 14, 58 pp., illus. Kiev.

A NOTE ON DDT, THE NEW SYNTHETIC INSECTICIDE*

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The following statement concerning dichloro-diphenyl-trichlorethane, or 2, 2-bis (parachlorophenyl) -1,1,1-trichloroethane, more conveniently referred to as DDT, has been prepared in view of the widespread interest among entomologists in this product and in its pest control possibilities. It is based on information obtained from various sources.

DDT was first made in 1872 in Strasbourg by a chemist named Zeisler, who published a description of the compound and the method of making it in a German chemical journal, without giving any indication of its usefulness. In recent years J. R. Geigy, S.A., dyestuff manufacturers, synthesized DDT and, on discovering that it had outstanding insecticidal properties, marketed insecticides containing this compound under the names of Gesarol and Neocid in Switzerland, where they have been used extensively on fruit and vegetable crops for the past two years or more.

British patents covering DDT as an insecticide were issued in London on September 15, 1942, and the United States patents were granted to Geigy a year later (September 7, 1943). The Canadian patent bears the number 411,926.

DDT is made by condensing monochlorobenzene and chloral in the presence of sulphuric acid. According to report, the manufacture of crude DDT is

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a comparatively simple operation, but production of the pure chemical is more difficult and expensive. However, there is said to be no advantage in using the chemically pure product, as commercially pure DDT is equally as toxic to insects. In the United States it is manufactured by the Cincinnati Chemical Works at Norwood and St Bernard, Ohio, and is distributed by the Geigy Company, Inc., 89 Barclay Street, New York City.

The several forms of DDT bearing Geigy's trade names are: GNB-A, and GNB-A-DDT, both commercially pure DDT; Gesarol A Dust, 3% DDT; Gesarol A Spray, 5% DDT; Neocid No. 15, containing 10% DDT; and Gesarex, a combined insecticide and fungicide containing DDT as the insecticide ingredient.*

DDT has been used effectively against insects in the form of dusts, sprays, emulsions and aerosols. It is a white, solid substance, which is insoluble in water. It is reported to be soluble in a number of organic solvents including cyclohexanone, xylene, dibutyl phthalate and benzyl benzoate, and it may be dissolved in kerosene up to 5 or 7 per cent.

DDT has a slow knockdown, but leaves a residue which may remain toxic to various kinds of insects for periods extending up to several weeks. The results of studies made in the United States which demonstrate this quality have not yet been made public. However, an article entitled "Gesarol in Stable Fly Control", by R. Weismann, Assistant Director of the Swiss Federal Agricultural Station at Wädenswil, Switzerland, which was originally published in German under the title "Eine Neue Methode der Bekämpfung der Fliegenplagen in Ställen", in Anzeiger für Schädlingskunde, Berlin, Vol. 19, No. 1, pp. 5-8, 1943, and translated by Carlo Zeimet of the Bureau of Entomology & Plant Quarantine, appeared in *Soap*, Vol. 19, p. 117, December, 1943. House flies, stable flies, and certain other common species were involved. A horse stable and a cow stable were sprayed with a 1% solution of Gesarol, applied thoroughly to walls and ceilings. The author states that: "This method is efficacious for five or six weeks and eliminates all the irritation and difficulties caused by these pests. The flies entering the stable are paralyzed in a short time by coming in contact with the spray deposits on the walls and ceilings . . . Owing to the satisfactory, prolonged potency of 'Gerasol' the livestock became remarkably quiet and milk production increased in the stables treated with this insecticide . . . . Spraying the stables twice in summer, the first time in the early half of June and the second time at the beginning of August, will eliminate the fly plague in stables for the whole summer."

DDT has also been shown to be very effective in the control of such insects as lice, bedbugs, mosquitoes, etc, and should find wide application as a household and industrial insecticide, and in the field of public health. Indications are that it has great promise as an agricultural insecticide. Excellent or encouraging results have been reported from its use against the codling moth, Japanese beetle, oriental fruit moth, fruit worms, and certain other pests of fruit, and against a number of insects attacking field and garden crops, such as corn earworm, European corn borer, cabbage worm, armyworm and the Colorado potato beetle.

Considerable research is being carried out in the United States on the insecticidal properties of DDT, and similar investigations in Canada have been incepted or are being planned. At present the total production of DDT, except for a small amount for channelized experimental purposes, is required for military use, but it is hoped that some may become available for civilian purposes in 1944.

*Since this article was written, another preparation has come to our attention, namely, Gesarol A20 Spray, which presumably contains 20 per cent DDT. Other mixtures are doubtless being prepared.

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